Lake Ice Phenology of Southwest Alaska

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Outline

- Rationale
- Methods
  - MODIS imagery
  - Image classification
  - In-situ observations
- Results
- Conclusions

Freshwater seals hauled out on Lake Iliamna

Wolves crossing lake ice

Salmon are a “keystone” species in the aquatic and terrestrial ecosystems of the region.

Alaskan communities depend on lake ice for transportation, subsistence and recreation.

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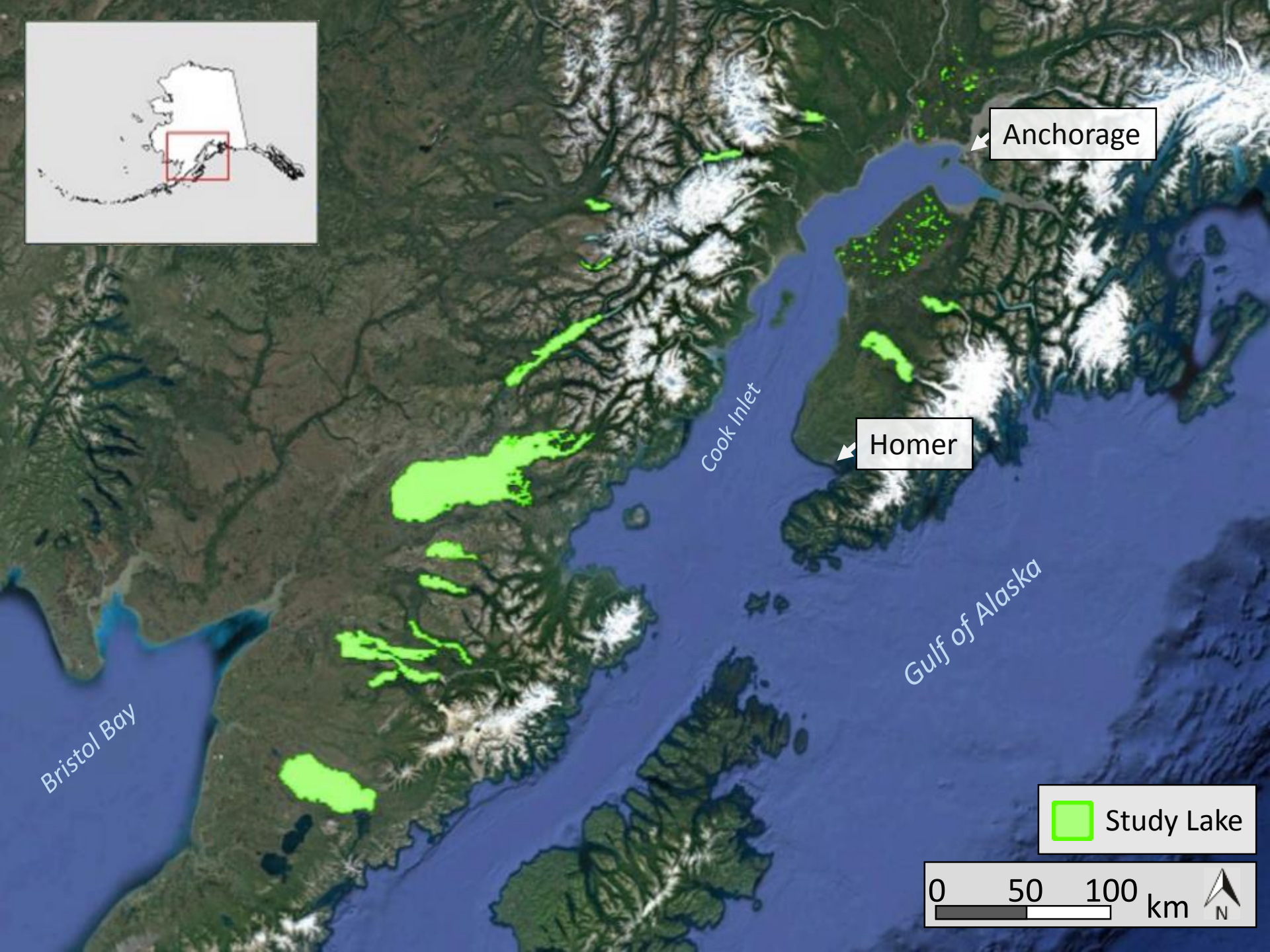
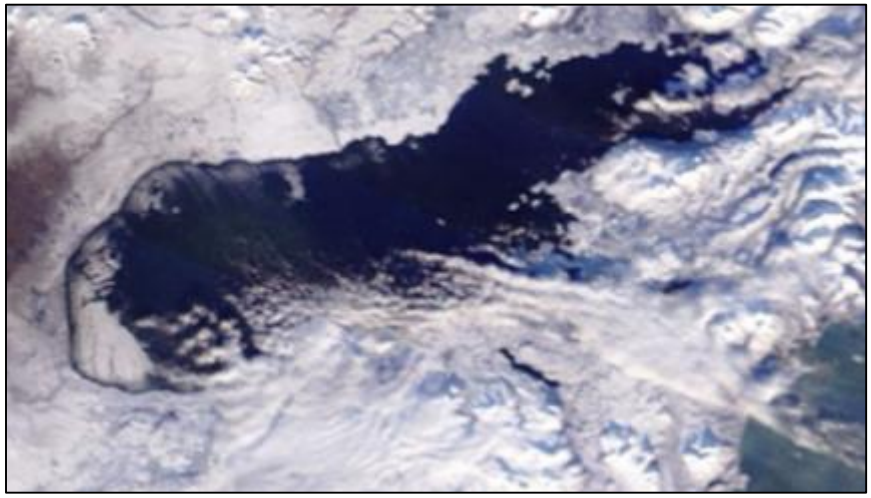
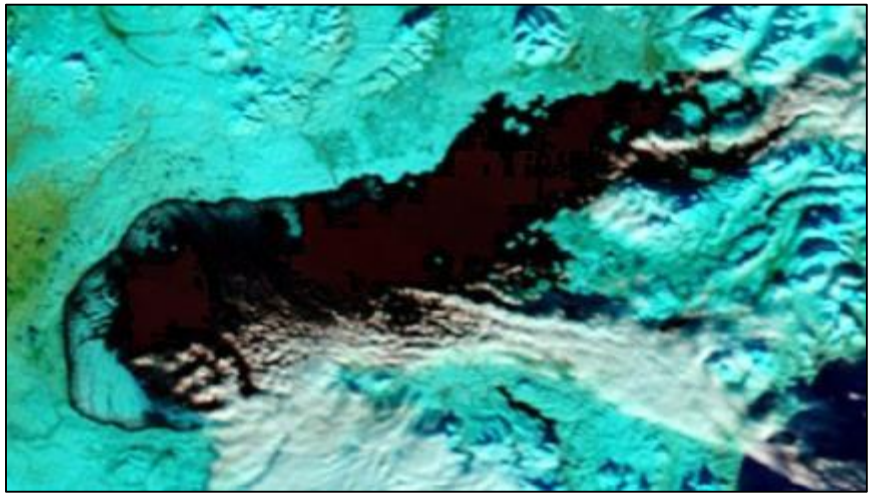

Anchorage
Homer
Cook Inlet
Gulf of Alaska
Bristol Bay
Study Lake
0 50 100 km
N

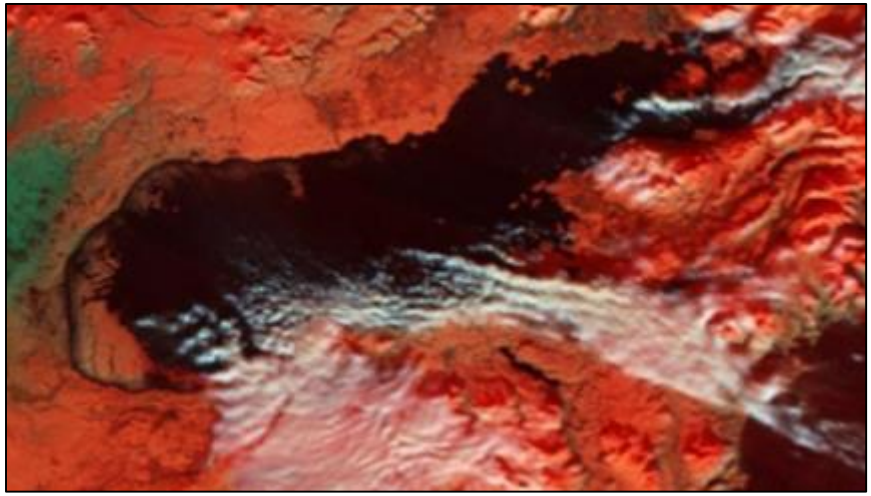
MODIS ‘Rapid Response’ Imagery



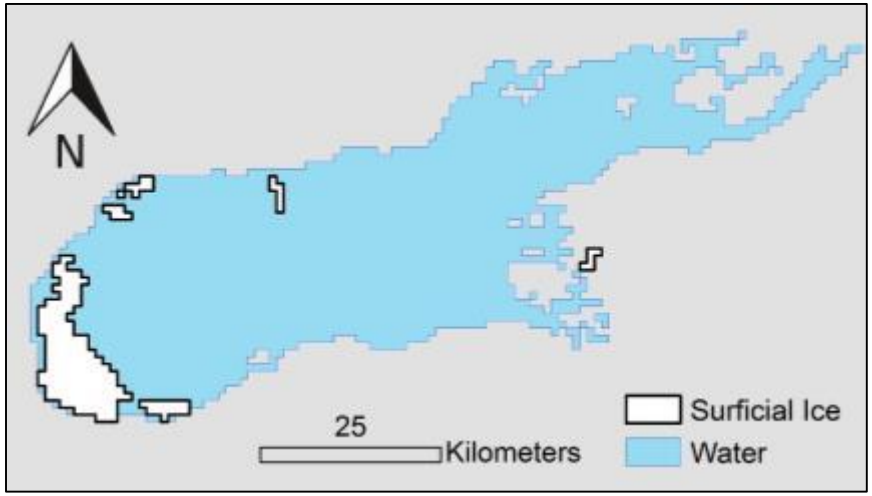
True Color (Bands 143)



Near Infrared & SWIR (Bands 721)



SWIR (Bands 367)

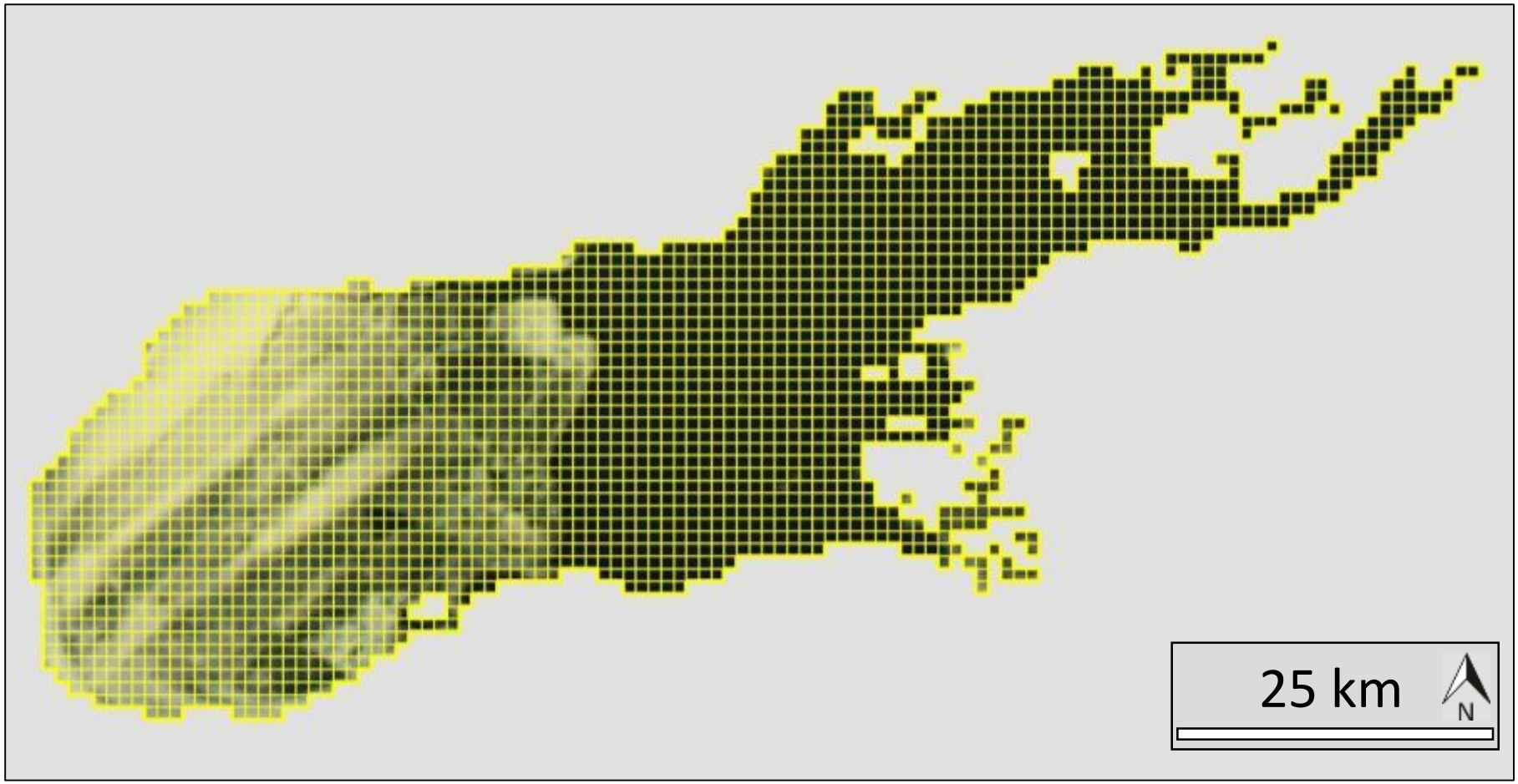


Lake Ice Phenology

We acknowledge the use of Rapid Response imagery from the Land, Atmosphere Near real-time Capability for EOS (Lance) system operated by the NASA/GSFC/Earth Science Data and Information System (ESDIS) with funding provided by NASA/HQ.

Manual Grid Analysis

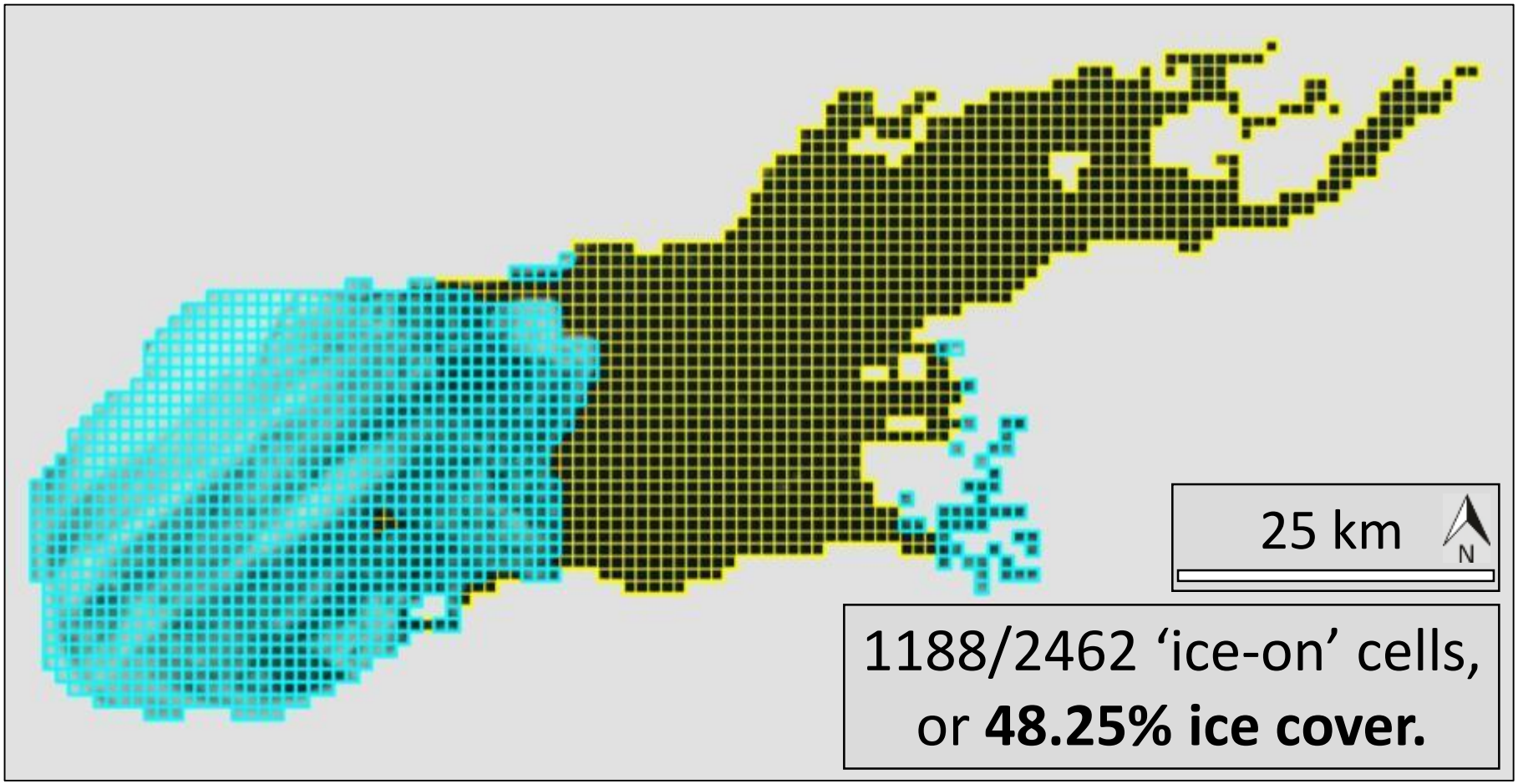
1 km^2 grid masked to lake margin:



Lake Iliamna, February 25, 2015

Manual Grid Analysis

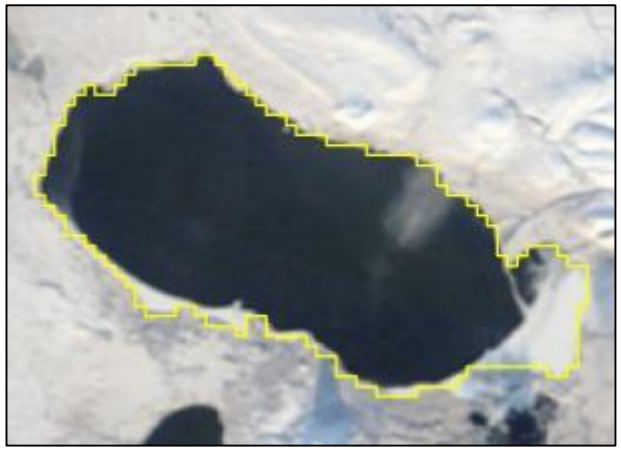
Selecting cells with >50% ice:



Lake Iliamna, February 25, 2015

Lake Becharof ice phenology during water year 2011:

October 11, 2010, 0% ice

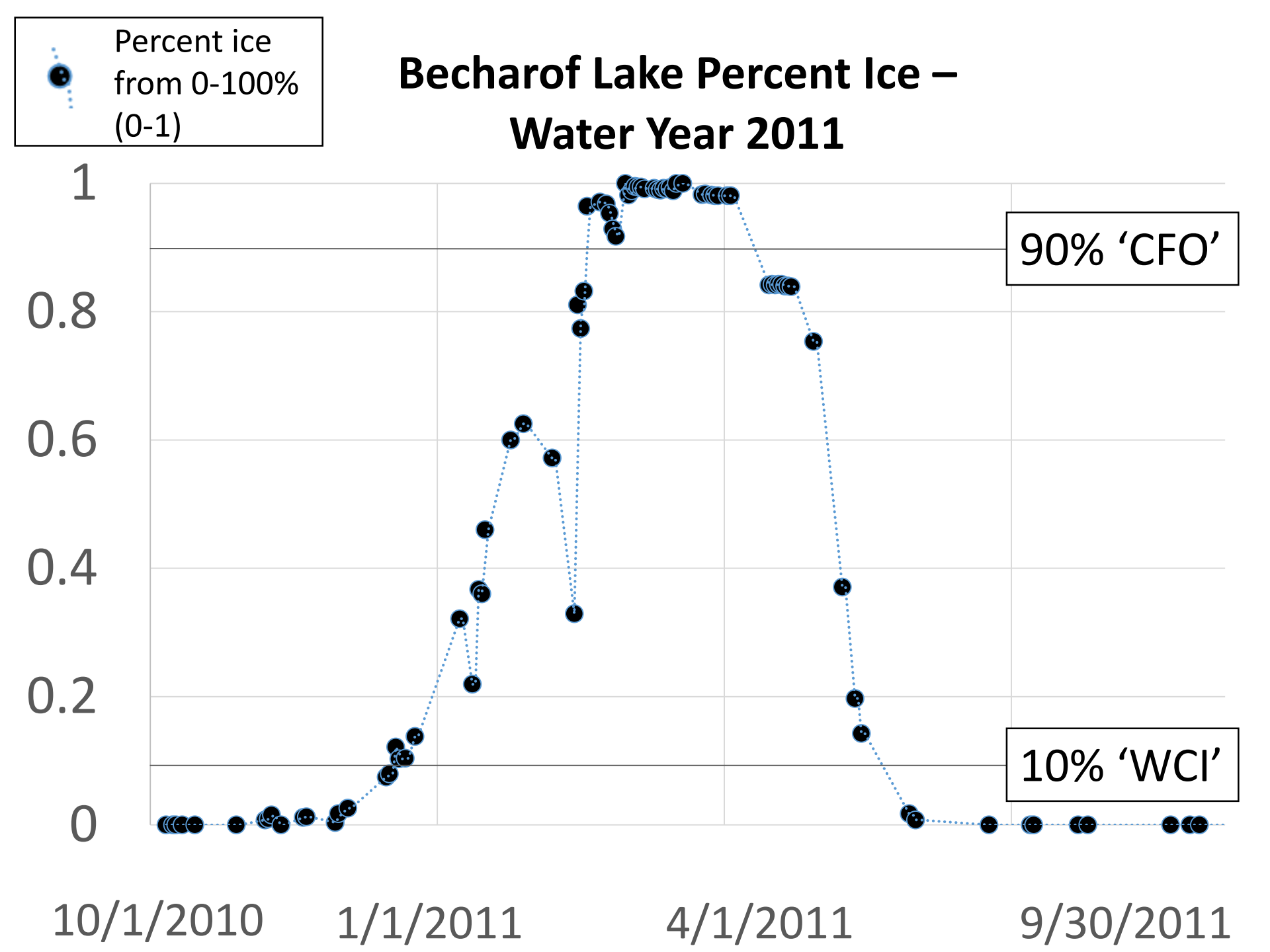


December 23, 2010, 14% ice

February 15, 2011, 92% ice

% Ice	Metric
≥10%	Start freeze-up
>90%	Complete Freeze-Over (CFO)
≤90%	Start break-up
<10%	Water Clear of Ice (WCI)

Williams, R.S., Jr., and Ferrigno, J.G., eds. (2012)


Percent ice from 0-100% (0-1)
Becharof Lake Percent Ice – Water Year 2011
1
0.8
0.6
0.4
0.2
0
90% 'CFO'
10% 'WCI'
10/1/2010
1/1/2011
4/1/2011
9/30/2011

Poor Visibility and Uncertainty

Threshold Midpoint =

Median of 2 closest clear days

± amount of clouded days between

Example:

Day 90: ~25%

Day 91-93: clouded

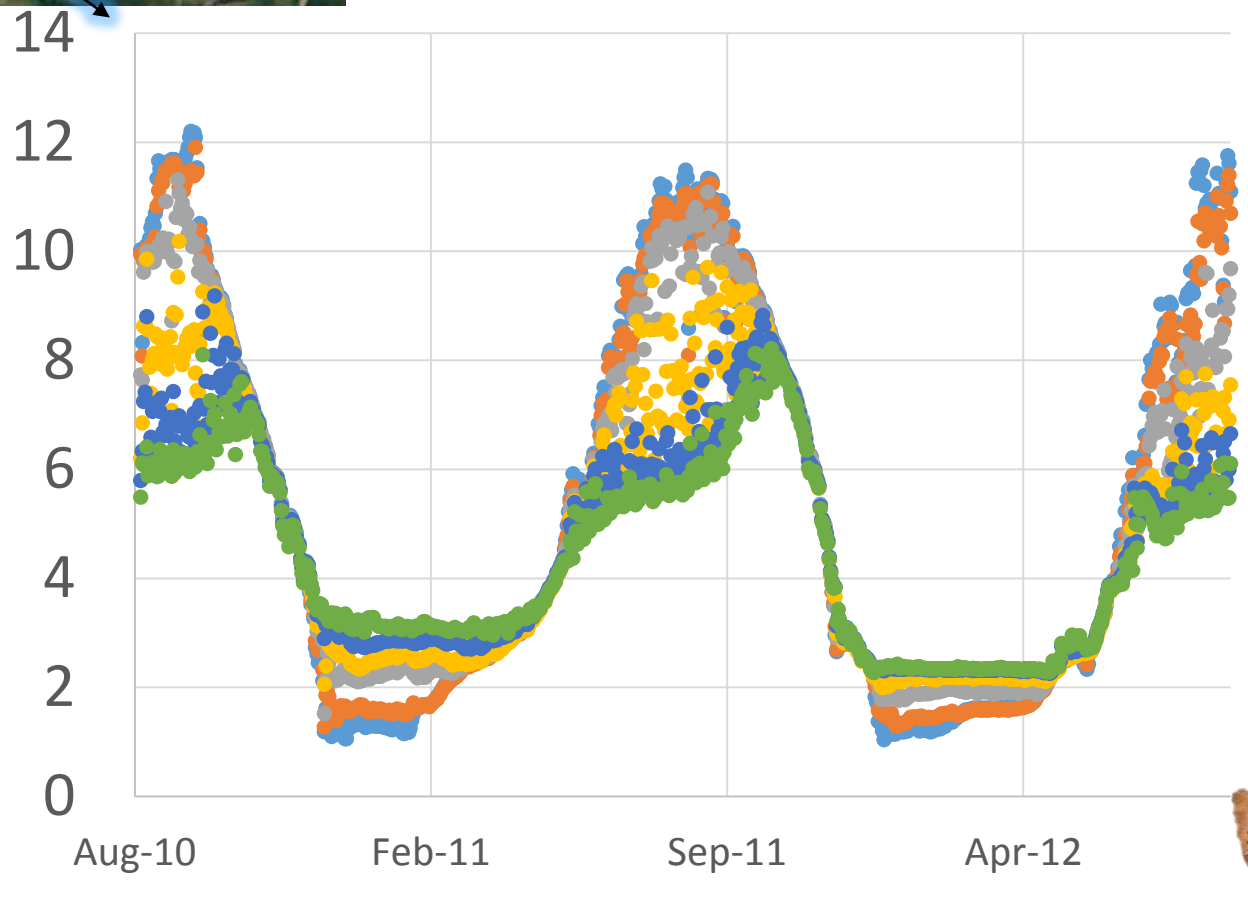
Day 94: 100%

Reported CFO date = <u>day 92</u> ± 3 days

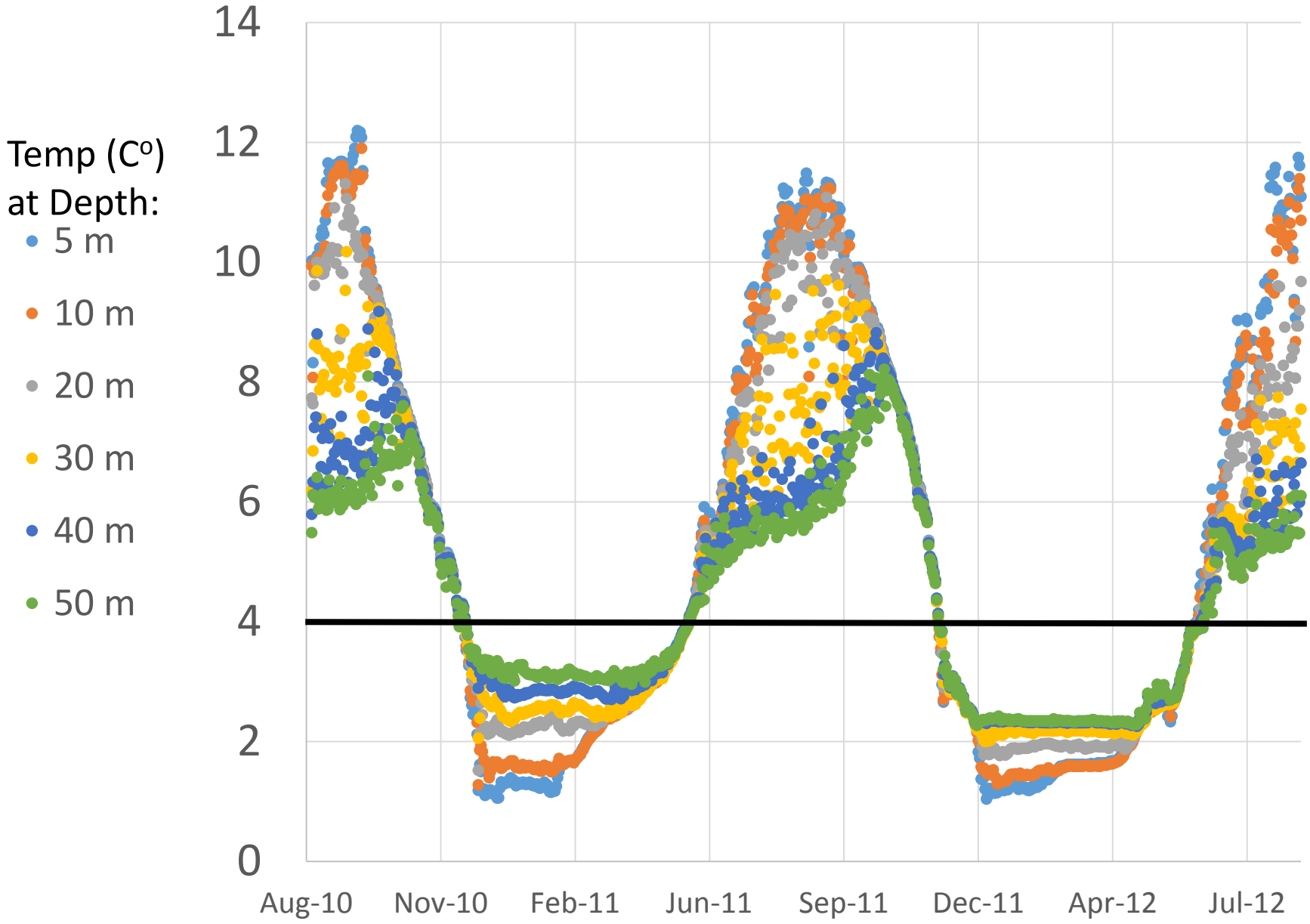
Lake Brooks Temperature Profile 2010-2012

Temp. (C°) at Depth:

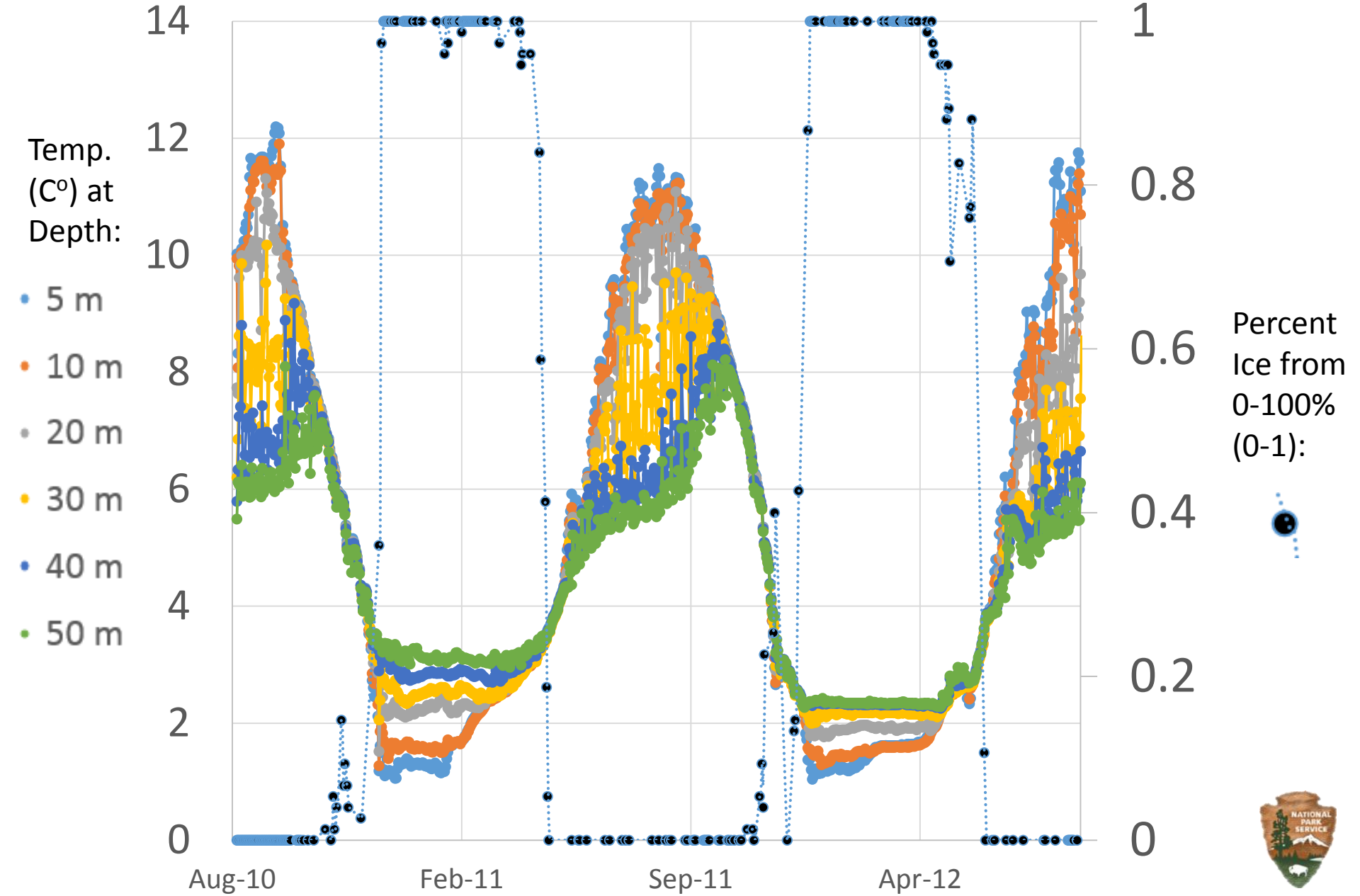
- 5 m
- 10 m
- 20 m
- 30 m
- 40 m
- 50 m



Lake Brooks Temperature Profile 2010-2012



Lake Brooks Temperature Profile & Ice Phenology 2010-2012



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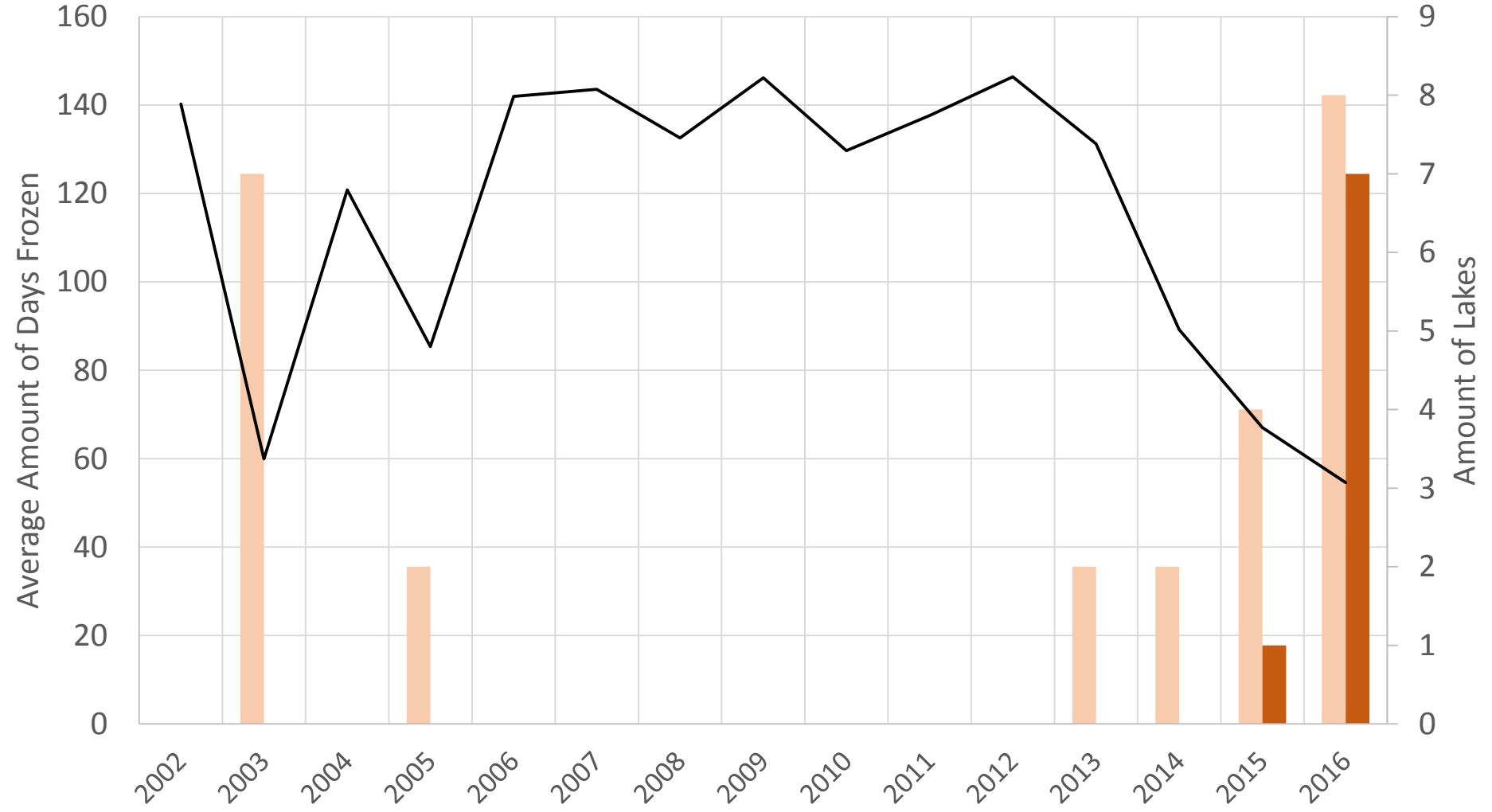
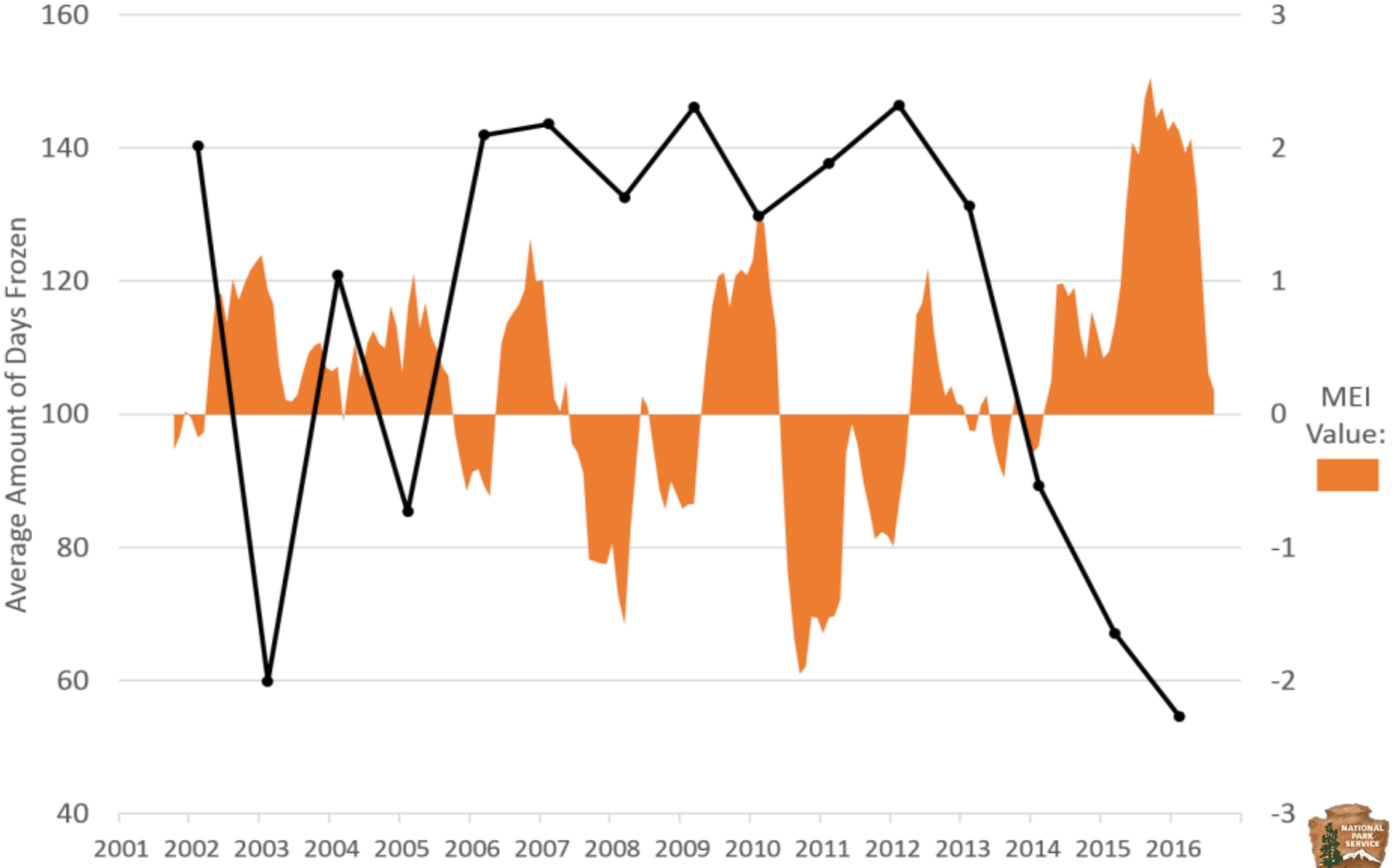
Ice Phenology Summary 2002-2016

- CFO ranges from late-Oct to mid-March (158 day variability)
- WCI ranges from early-Jan to late-June (174 day variability)
- Break-up more rapid (18.1 days ave.) than freeze-up (24.1 days ave.)
- Average duration of freeze (>90% ice): 115 days
  - Shortest years: 2003, 2015, and 2016, 55-67 days
  - Longest years: 2009 and 2012, 146 days each

Average Days Frozen & Amount of Lakes Failing to Meet 10% and 90% Ice Metrics

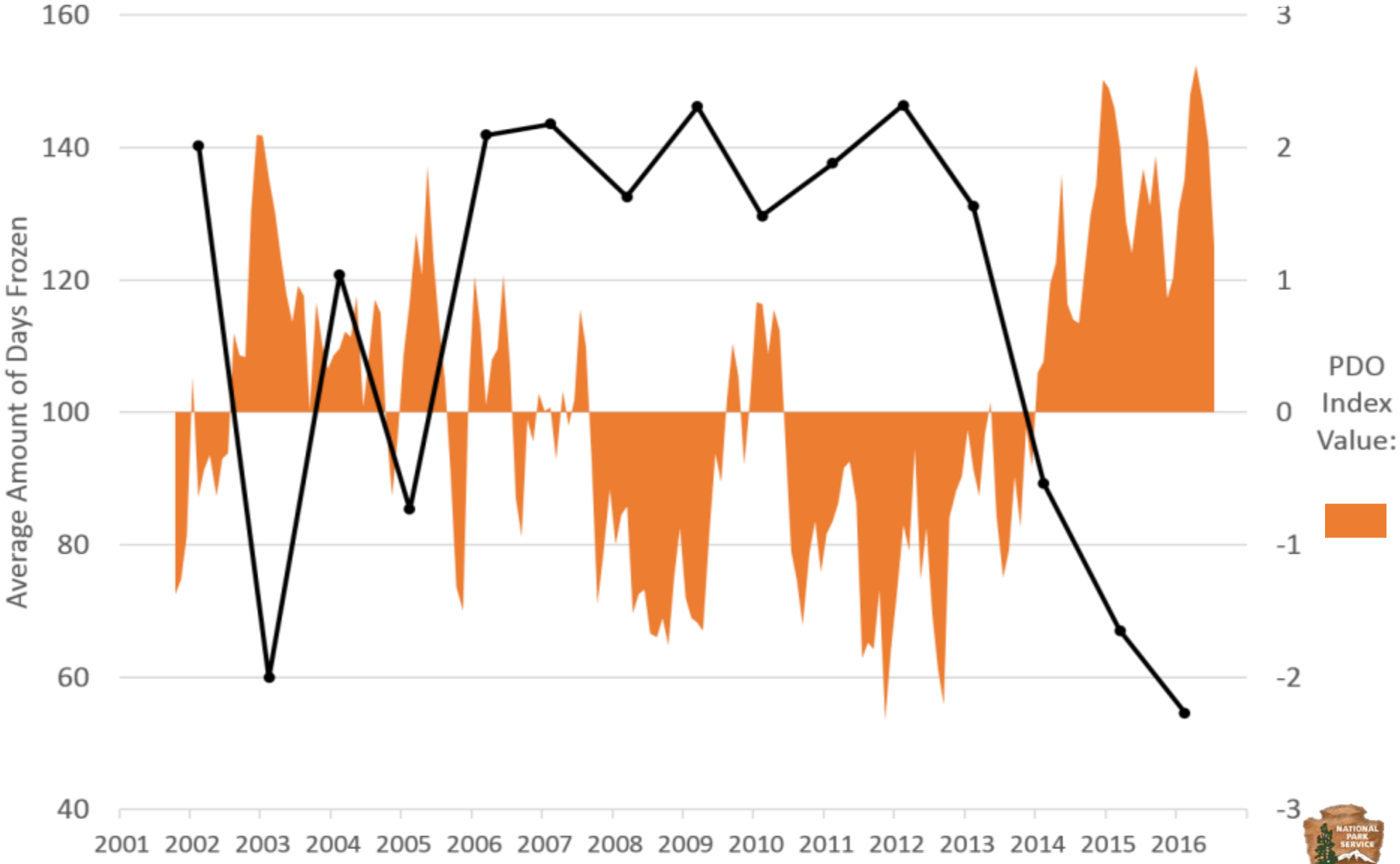


Multivariate ENSO Index (MEI) and Average Ice Duration Per Year



www.esrl.noaa.gov/psd/enso/mei/#ref_wt1

Pacific Decadal Oscillation (PDO) Index and Average Ice Duration Per Year



research.jisao.washington.edu/pdo

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Conclusions

- 15 year lake ice phenology available, publication 2016-2017
- Continued use in Bristol Bay and Cook Inlet fisheries, limnology, and hydrology research

Future Work

- Obtain earlier time series using radar satellite observations
- Identify the next high temporal resolution satellite platform

science.nature.nps.gov/im/units/swan/monitor/lake_ice_about.cfm

About this Network
Network Parks
Inventories
Monitoring
- Freshwater Flow Systems
- Landscape Dynamics & Seasonal Processes
  - Overview
  - Glacial Extent
  - Seasonal Processes
    - Lake Ice
  - Vegetation Composition
  - Sensitive Communities
  - Insect Outbreaks
  - Invasive Species
- Marine Nearshore
- Weather, Climate, & Air Quality
- Wildlife
- Repeat Photography

Data Management
Reports & Publications
Multimedia Files & Links

Lake Ice Data

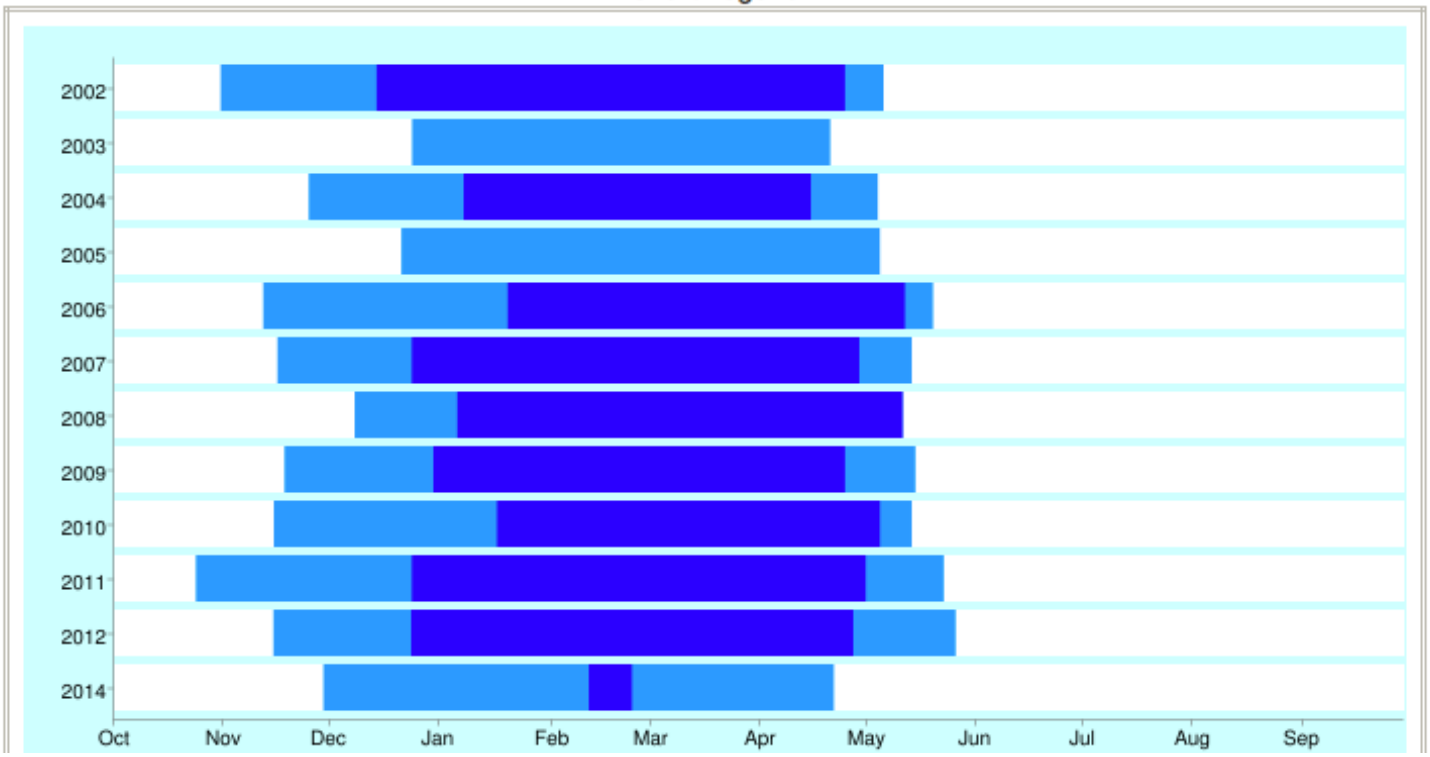
Back to map of lakes

Naknek Lake

Select a lake | Go

Lake has => 10% Ice | Lake has > 90% Ice

Chart Legend



Thank-you and Questions?

Many thanks to providers of in-situ data for validation:

- U.S. Fish and Wildlife Service
- Cook Inletkeeper
- University of Washington – Alaska Salmon Program

Average Ice Phenology Data by Year

Year	Days Frozen >90%	Days Freezing	Days Thawing	Lakes not reaching 10% ice	Lakes not reaching 90% ice
2002	140	20	23		
2003	59	25	22		7
2004	121	28	17		
2005	85	26	30		2
2006	142	25	8		
2007	144	21	13		
2008	133	14	9		
2009	146	26	11		
2010	130	27	14		
2011	138	36	17		
2012	146	26	20		
2013	131	26	34		2
2014	89	32	22		2
2015	67	15	19	1	4
2016	55	14	13	7	8
Average	*115.1*	*24.1*	*18.1*		